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**CHROMOSOME STUDIES IN THREE SPECIES OF
FELICIA WITH NOTES ON NOMENCLATURE**

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While on a visit to South Africa the first author obtained seeds of three species belonging to the tribe Astereae. On his return to Kentucky these were grown and a cytological investigation carried out. The cytological part of this paper is the outcome of these studies.†

Unfortunately in South Africa there is a considerable diversity of opinion with regard to both genera and species in the Astereae and the three species investigated reflect this uncertainty. Two of the species were obtained from the botanical garden of the Department of Botany of the University of Pretoria through the kindness of Mr. A. Berg. They were named *Aster capensis* and *Felicia bergeriana*. The third species was obtained from the National Botanic Gardens at Kirstenbosch through the kindness of Mr. H. Hall. This was named *Felicia rotundifolia*. It was soon apparent that if the cytological results were to have a real value, the names attached to the three species would have to be verified. At this point the co-operation of the second author was sought and in the present paper she is responsible for the taxonomic part.

Quite a wide range of problems present themselves in connection with the species. *Aster* is a Linnaean genus and most of the species described in the first edition of the *Species Plantarum*, belong to the northern hemisphere. *Felicia* was established by Cassini in the year 1818 for a group of African species allied to *Aster*. Harvey in the *Flora Capensis* kept up the genus *Aster*, sub-

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dividing it into two subgenera, *Felicia* and *Agathaea*. All the species with which this paper is concerned fall under the subgenus *Agathaea* of Harvey. Bolus and Wolley-Dod in the Flowering Plants and Ferns of the Cape Peninsula placed all the species of both subgenera in *Felicia*. This is the sense in which the genus *Felicia* is understood by botanists working in the herbaria in Cape Town. E. P. Phillips in the second edition of the Genera of South African Plants reverted to the old treatment and regarded *Felicia* as a synonym of *Aster*. Thus a species may be placed in *Aster* in the Transvaal while the same species will find itself in *Felicia* in the Cape. Admittedly this is a most unsatisfactory state of affairs and there is no doubt that the species of the tribe *Astereae* are sadly in need of revision.

The second author adopted *Felicia* in the Flora of the Cape Peninsula largely as a matter of expediency. *Aster exilis* is a weed of cultivation on the Cape Peninsula, a most insignificant plant but one which raised a problem in nomenclature. The relationship between *Aster exilis* and the Michaelmas Daisies of our gardens is obvious but it is equally obvious that the South African species, though allied, form a distinct group. For this reason *Felicia* was retained for the native species and *Aster* applied to the northern species only.

PROBLEMS PRESENTED BY THE THREE SPECIES INVESTIGATED

1. *Felicia amelloides* (L.) Voss

Reference Levyns 11,252 in the herbarium of the Botanical Department, University of Cape Town.

Amelloides is the correct specific epithet for the plant named *Aster capensis* in the botanic garden of the University of Pretoria. It is a low shrub, commonly found in gardens throughout South Africa and elsewhere. It has a prolonged flowering season and its blue ray florets contrasted with the yellow disc florets make it an attractive garden plant. It is generally known to nurserymen either as *Aster capensis* or *Felicia capensis*. Its home is along the coastal strip from about Hermanus to the Kei River mouth, but there are no records of it as far to the west as the Cape Peninsula. It is now clear that *amelloides* is an older specific name than *capensis* for this species. The Compton Herbarium acquired recently a set of microfiches of the Linnaean Herbarium and this has made comparison in South Africa possible whereas formerly a journey to London was necessary. There is no doubt at all that the Linnean species *Cineraria amelloides* is the present species. The synonymy is therefore, *Felicia amelloides* (L.) Voss in Vilmorin's *Blumeng.* ed.3, Sieb. & Voss

Aster capensis Less.Syn. Comp. 168 (1832)

Agathaea coelestis Cass.Bull.Philom. (1815)

Agathaea amelloides DC. V 225 (1836)

Cineraria amelloides L.Sp.Pl. ed.2 (1762). Mill.Icon.t.76 fig.2.

During the preparation of the Flora of the Cape Peninsula, the Linnaean Collection was not available for study owing to wartime conditions and therefore the identity of *Cineraria amelloides* could not be established. A species related to the species under discussion, occurs on the Cape Peninsula and the second author relying on Thunberg's statement in his *Flora Capensis* that *Cineraria amelloides* grew on Table Mountain, accepted this as true. As a result another species was mistakenly named *Felicia amelloides*. This species must now revert to the name *Felicia aethiopica* (Burm.f.) Bolus & Wolley-Dod, while the epithet *amelloides* is restored to the species typified in the Linnaean Herbarium.

2. *Felicia rotundifolia* (Thunb.) comb.nov.

Reference Compton 23,655 in the Compton Herbarium in the National Botanic Gardens, Kirstenbosch.

It is very dubious as to whether this is the correct name for this species. Harvey when he was preparing the *Flora Capensis*, saw Thunberg's specimen and came to the conclusion that it was merely a young plant of the species now known as *Felicia amelloides*. He named it *Aster capensis* var. *rotundifolius*. In view of the first author's cytological findings presented in this paper, it is evident that Harvey was wrong. However, there is no certainty that Thunberg's species is the same as the species now bearing this name at Kirstenbosch. A visit to Thunberg's Herbarium in Uppsala is the only way of deciding whether the present species is the same as Thunberg's. Even if it should turn out to be the same the combination *Felicia rotundifolia* is already in existence, probably for some other species. In the *Index Kewensis* the taxon *Felicia rotundifolia* is cited as follows: "G. C. Taylor in New Fl. & Silv. III. 118 (1931)". This work has not been seen by the authors but there is nothing to suggest that it is a new combination of Thunberg's species. Thus it is important that material of the species used in these studies be preserved so that even if the name prove to be wrong, the identity will not be in doubt. The reference given above will ensure this. Compton 23,655 was collected at Mossel River to the east of Hermanus and is an excellent match of the plant growing at Kirstenbosch under the name *Felicia rotundifolia*.

3. *Felicia bergeriana* sensu hort. non Bolus & Wolley-Dod.

Reference Scheepers 1221, in the herbarium of the Botanical Department, University of Cape Town.

Felicia bergeriana was first described by Sprengel in 1826 under the name *Cineraria bergeriana* (II). His description is meagre, he cites no specimen and merely states that it came from South Africa. Six years later a good and full description was given by Lessing (7) under the name *Elphegea bergeriana*, and he states that it is the same species as *Cineraria bergeriana* Sprengel. His

diagnosis ties down the species for he states that it is an annual, that it has sterile disc but fertile ray florets and that it was collected by Ecklon on the Lion's Rump above Cape Town. A species answering this description was until a few years ago, locally common in that area, so there is no doubt about the plant Lessing meant. Subsequently the species was transferred to *Aster* by Harvey and later to *Felicia* by Bolus and Wolley-Dod.

The material used by the first author in his cytological studies was obtained from seedlings grown from seeds given to him by Mr. Berg of the University of Pretoria under the name *Felicia bergeriana*. The second author being familiar, with *Felicia bergeriana* in its wild state, felt dubious about the correctness of the name given to the Pretoria plant. *Felicia bergeriana* is an inconspicuous annual and not likely to have any horticultural value. Thanks to the kindness of Dr. L. E. Codd and Professor H. G. Schweickerdt, material of the Pretoria plant has been made available and, as suspected, belongs to another species. Unfortunately owing to our imperfect knowledge, it is not possible at the present time to name the species. Specimens have been preserved and when in due course *Felicia* receives the attention it merits, the species will be named. It may well prove to be one of the little understood species with which this genus abounds and for this reason a new taxon has not been created.

Dr. Codd has attempted to trace the history of this species in the gardens of Pretoria and some interesting facts have emerged. The University of Pretoria got their original seed from the Division of Botany. Mr. Erens who was formerly head gardener at the Division of Botany, thought that seed had come from plants growing in the gardens of the Union Buildings and that their seed might, in the first instance, have come from the well known firm of Sutton in England. Novelties have in the past been introduced into European gardens by these enterprising seedsmen and it may well be that the so-called *Felicia bergeriana* cited by Darlington and Wylie (4) and the species investigated here, may be traced back to the same source. The fact that the same chromosome number is given in both cases, supports this conjecture.

CYTOLOGICAL RESULTS

Materials and methods

Chromosome studies were made from the root tips of germinating seeds which had been sown in sterilized soil. When the roots were about 1—2 cm. long, the seedlings were dug up and slides were prepared from their root tips by slight modifications of the technique of Bhaduri and Ghosh (1954). The effect of this technique was to cause the chromosomes to spread out and separate from one another so that they could more easily be counted and to cause the chromosomes to shorten considerably and their chromatids to diverge so that

they frequently had the appearance of an X. At least twenty cells of each species were studied and drawn. The measurements recorded in the tables reflect the averages of these cells. Chromosomes were arranged in homologous pairs by considering together those chromosomes that were most alike with respect to the ratios of the short arm to the long arm and of the short arm to the length of the chromosome, disregarding the length of the centromere in the pair of chromosomes with a long, attenuated centromere in *F. rotundifolia*. Measurements in the two tables represent the averages of the two chromosomes of a homologous pair. Ideograms have been drawn for each species (figs. 2, 4 and 6).

Chromosomes were studied with a Leitz ortholux microscope using an oil immersion plano-apochromatic objective of 100X magnification and 1.32 N.A. and at a magnification of X 3,000. The slides were prepared by Dr. Victor J. Hoff and Mr. Debdas Mukerjee but were studied by the first author who takes full responsibility for the interpretation.

Observations

Felicia amelloides. The somatic chromosome number is 18 (Fig. 1), the average length of the individual chromosome is 4.7μ , and the range is from 3.5μ to 5.8μ . If the pairs of homologous chromosomes are classified as in Delay's list of chromosome numbers wherein chromosomes less than 3μ are regarded as short, those from 3μ to 6μ as intermediate and those above 6μ as long, all chromosomes would fall in the intermediate category. This classification does not appear to be sufficiently discriminatory, so a classification based on 1μ intervals was adopted. As can be seen from Table 1, the range of lengths covers three intervals with the majority of chromosomes in the $4.1-5.0$ class. An index of relative lengths of the two chromosome arms of the homologous pairs was obtained by dividing the shorter arm of each chromosome by the longer (Table 2). The indices range from 0.39 to 0.93; the average index for the nine pairs of chromosomes is 0.68 and the median is 0.67. One pair of chromosomes has a rather marked secondary constriction (Fig. 1).

Felicia rotundifolia. The somatic chromosome number is 16 (Fig. 3). The individual chromosomes range in length from 2.2μ to 4.0μ and the average length is 3.5μ . Table 1 shows that they are almost equally divided between the $2.1-3.0$ and the $3.1-4.0\mu$ intervals. When the indices of the ratios of the short arm to the long arm are computed for the homologous pairs, they are found to range from 0.33 to 0.86 (Table 2); the average index is 0.49 and the median lies between 0.44 and 0.47. One pair of chromosomes has an elongated, attenuated centromere (Figs. 3 and 4). These centromeres appear very long in some cells, rather short in others, but generally long. Because of their length, careless observation could easily cause the short arm to be regarded as an extra

chromosome and the sporophytic number to be 18, but even when the thin connecting thread is scarcely visible, the position of the small arm to the long one usually suggests that it is not a separate chromosome. Because of the possible confusion, cells were studied independently by Dr. Hoff, Mr. Mukerjee and the first author. Each arrived at a sporophytic number of 16. In a few of the cells one chromosome appears to have a satellite on its short arm, but it is not clear. One chromosome seems to have a secondary constriction but it is not as clear as that in *F. amelloides* and may be illusory.

Felicia bergeriana sensu hort. The somatic chromosome number of this plant has been recorded as 12 (Bilquez, 1951, cited in Darlington and Wylie, 1956) and this report is confirmed by the present study (Fig. 5). The average length of the chromosomes is 2.86μ and the range is from 2.5 to 3.3μ . They are divided between the two intervals $2.1-3.0 \mu$ and $3.1-4.0 \mu$ (Table 1), but two thirds of them are in the smaller class. The indices computed by dividing the short arms by the long ones range for the homologous pairs from 0.40 to 0.88 (Table 2) with an average index of 0.63 and a median between 0.58 and 0.67 . One pair of chromosomes has a clear satellite on the short arm (Figs. 5 and 6).

The average lengths of the chromosomes as well as the ratios of the long arm to the short, differ in the three species. Even though the measurements were taken from chromosomes shrunk by α -bromonaphthalene and 8-oxyquinoline, they are relatively accurate since there is no *a priori* reason to suppose that the chromosomes in the different species of one genus, respond differently to pre-treating agents. The differences between the species are brought out in Tables 1 and 2. Some morphological features are not so obvious. A pronounced secondary constriction is present in one pair of chromosomes of *F. amelloides*, while in *F. rotundifolia* there is an indication of a secondary constriction in at least one chromosome, although it is not clear. *F. amelloides* does not appear to possess any satellites, one chromosome *F. rotundifolia* has a somewhat indefinite satellite, while one in *F. bergeriana* has a clear one.

The results of this investigation show that cytology may well play an important part in future studies on the Astereae in South Africa. Harvey's view that *Felicia rotundifolia* is merely a variety of *Felicia amelloides* is clearly disproved by the present research for the two taxa differ not only in their basic chromosome number but also in their chromosome morphology. Combined taxonomic and cytological research give promise of solving many of the problems which confront us in this group at the present time.

Another feature brought out in this work is the need for a preserved and numbered specimen, lodged in a recognised institution. When name changes have to be made, as they undoubtedly will in *Felicia*, cytological results have a permanent value if a specimen be available to which reference may be made.

At present there is no guarantee that a name given to a species by one worker is not used to denote another species by a second worker. A case in point is *Felicia amelloides*. In Darlington and Wylie's Chromosome Atlas *Felicia amelloides*, with the popular name Blue Daisy added as an aid to identification, is given as having a somatic chromosome number of 16. No authority is quoted for the species. At least three distinct taxa have masqueraded under this epithet in the past. Furthermore, blue daisies are so common in South Africa that the use of this popular name has no value. The fact that the species cited in Darlington and Wylie has a somatic chromosome number 16, makes it almost certain that the plant investigated by Sugiura was not *F. amelloides*. The number 18 given in this paper belongs to the true *F. amelloides*, as typified by *Cineraria amelloides* of Linnaeus.

Taxonomists some years ago were forced to adopt the type system in order to ensure accuracy of naming. It appears that cytologists will be forced to adopt a similar plan in order to obviate the possibility of a laborious investigation being rendered valueless because the identity of the plant studied cannot be verified.

TABLE I.

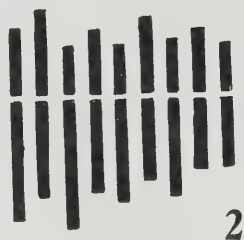
Number of somatic chromosomes of *Felicia amelloides*, *Felicia rotundifolia* and *Felicia bergeriana* classified according to their lengths.

Length in micra		<i>F. amelloides</i>	<i>F. rotundifolia</i>	<i>F. bergeriana</i>
5.1—6.0		3	0	0
4.1—5.0		5	0	0
3.1—4.0		1	5	2
2.1—3.0		0	3	4

TABLE II.

The number of somatic chromosomes in *F. amelloides*, *F. rotundifolia* and *F. bergeriana* placed in various classes distinguished by the ratios of the length of the shorter to that of the longer arm.

Ratios		<i>F. amelloides</i>	<i>F. rotundifolia</i>	<i>F. bergeriana</i>
0.90—0.99		2	0	0
0.80—0.89		1	1	1
0.70—0.79		1	0	2
0.60—0.69		1	0	0
0.50—0.59		2	1	1
0.40—0.49		1	3	2
0.30—0.39		1	3	0



5
0 μ

KARYOTYPES

3
0 μ

IDEOGRAMS

REFERENCES.

1. ADAMSON R. S. and SALTER T. M. Flora of the Cape Peninsula. Juta & Co. Ltd. Cape Town. 1950.
2. BHADURI P. N. and GHOSH P. N. Chromosome squashes in cereals. *Stain Tech.* **29**. 1954.
3. BOLUS H. and WOLLEY-DOD A. H. The flowering plants and ferns of the Cape Peninsula. *Trans S.Af.Phil.Soc.* **14**. 1904.
4. DARLINGTON C. D. and WYLIE A. P. Chromosome atlas of flowering plants. Allen and Unwin. London.
5. DE CANDOLLE A. P. *Prod.Syst.Nat.* **5**. 1836.
6. HARVEY W. H. and SONDER O. W. Flora Capensis 3. 1864-65.
7. LESSING C. F. Synopsis genera Compositarum 1832.
8. Linnaeus C. Species Plantarum ed.2. 1762.
9. PHILLIPS E. P. The Genera of South African Flowering Plants. ed.2. 1951.
10. RAVEN P. H., SOLBRIG O. T., KYHOS D. W. and SNOW R. Chromosome numbers in Compositae. I. Astereae. *Amer.Jour.Bot.* **47**. 1960.
11. SPRENGEL C. Systema Vegetabilium Linnaeani. ed. 16. 1862.